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have the marginal definition clear, I have used a small diaphragm, No. 3, with an opening about half-an-inch in diameter, and consequently the time of exposure has been somewhat long, varying from one and a half to three minutes. Some of the models are a good deal discoloured by age and rough treatment; and in order to obtain sufficient contrast in the different parts, I have had either to recolour them with ordinary water-colours, or to coat them over entirely with white. For the latter purpose I have used kaolin, mixed with gum and water, with the best results; it gives a very perfect dead-white surface, and can, moreover, be removed with the greatest ease.

ROBERT CAMERON GALTON.

Feb. 14, 1865.

IX.—*Water Supply in the Basin of the River Orange, or 'Gariep, South Africa.* By JAMES FOX WILSON, Esq.

Read, March 13, 1865.

A VERY noticeable physical fact, which has of late years attracted considerable attention from residents in South Africa, is the gradual drying-up of large tracts of country in the Trans-'Gariep. That great expanse of wilderness, called the Káláhári, remarkable for few inhabitants, little water, and considerable vegetation, seems to be gaining in extent, gradually swallowing up large portions of the habitable country on its confines, and slowly, but surely, assimilating their fertile character to its own sterile one. It has become matter of notoriety that springs, which a few years ago supplied a sufficient quantity of fluid to irrigate considerable breadths of garden and field, have diminished in their flow and dwindled away, causing the migration of the inhabitants to a more favourable dwelling-place; while desert sucking-places and well-filled pools, such as that of Serotli, described by Livingstone, are at present either completely dry, or afford only a small quantity of liquid after much digging, where formerly existed a large piece of water.

At Lopépe and other places on the road to Lake 'Ngami this is the case, as well as at Tunobis in Damaraland, and elsewhere; but it is most conspicuous in the territory of the Bakwain tribes, in which, as one of the many evidences of the growing desiccation of the country, streams, *e. g.* the Mahalapi River, that at Lopelóle and at Porapora Pass, are pointed out where thousands and thousands of cattle formerly drank, but in which water never now flows, and where a single herd could not find fluid for its support.*

* Livingstone, pp. 14, 150.





When Mr. Moffat first attempted a settlement at the Kúrúman forty years ago, he made a dam six or seven miles below the present one, and led out the stream for irrigation, where not a drop of the fountain water ever now flows; and other parts, fourteen miles below the Kúrúman gardens, are pointed out as having contained, within the memory of people now living, hippopotami and pools sufficient to drown both men and cattle.*

The fountain at Griqua Town, which a few years ago yielded a sufficiency of water to irrigate four square miles of corn and garden ground, has of late years and in the most marked manner diminished its supplies, almost ceasing to flow, and occasioning the emigration of many of the Dutch-speaking inhabitants to other and more fertile localities not subject to the absence of moisture.

As this diminution of water has been coincident with the failure of fountains over a wide extent of territory in Bechuanaland, it is evident that from some cause, more or less obscure, *a great change in the external physical characteristics of the entire region between the Orange and the 'Ngami Lake, has taken place since the country was first explored by Europeans.*

This great change has not, however, been confined to the comparatively short space of time during which missionaries have been in the country. On the contrary, the traditions of the natives point to more remote periods, when the country was far more fertile and much better watered than at present—when the Kúrúman and other rivers, with their impassable torrents, were something to boast of. Moffat says that accounts of floods of ancient times, of incessant showers which clothed the very rocks with verdure, and of the existence of giant trees and forests which once covered the brows of the Hambana Hills, are wont to be related by garrulous elders, to the utter astonishment of their younger listeners. In those ancient days the lowing herds walked up to their necks in grass, and, filling their owners' milk-sacks with rich milk, made every heart to sing for joy.†

But, independent of this oral and traditional testimony, travellers have before their eyes, in the immense number of stumps and roots of enormous trunks of the Acacia giraffe, where now scarcely a single living specimen is to be seen raising its stately head above the shrubs, and in the ancient beds of the dried-up rivers Matlaurin, Mashaua, Molapo, and others, positive demonstration of the departed former fertility of the lands of the Bechuana nation. In fact, the whole country north of the Orange River, and lying east of the Káláhári Desert, presents to the eye of a European, to use the words of the missionary just quoted, "something like an old neglected garden or field."

* Livingstone, p. 110.

† Moffat's 'South Africa,' p. 86.

In investigating the causes which have combined to produce these desolating effects in the Basin of the 'Gariep, it will be necessary for us to dismiss from our minds all theories of cosmical changes; for although at first sight so gradual, extensive, and so marked a diminution of water-supplies might give rise to an idea of the presence of subterranean agency in some form, yet we cannot find that the parts of Africa under consideration are or have been in the past subject to the ravages of earthquakes. If an upheaval, due to agencies operating beneath the surface of the earth, *were* taking place, it must be of extremely slow and almost imperceptible action, and could scarcely be made to account for the present increasing growth of the droughty region. Cosmical convulsions, such as the disruption of hills, the production of faults in strata, and the forcing of river-gorges, may possibly afford us an explanation of the draining out of ancient lakes towards the ocean; but in the case of the gradual diminution of fountains and the final disappearance of rivers no convulsion of nature can be adduced in explanation, neither has any such violent natural operation been observed since Europeans have lived in the country.

Perhaps Dr. Livingstone lays too much stress on his ingenious theory of the forcing of the gorge of the Mosioatunya Falls? * He

* . . . "The path seemed to lead along the high bank of what may have been the ancient bed of the Zambesi before the fissure was made. The Lekone now winds in it in an opposite direction to that in which the ancient river must have flowed. Both the Lekone and Unguesi flow back towards the centre of the country, and in an opposite direction to that of the main stream. It was plain then that we were ascending the further we went eastward. The level of the lower portion of the Lekone is about 200 feet above that of the Zambesi at the Falls, and considerably more than the altitude of Linyanti; consequently, when the river flowed along this ancient bed, instead of through the rent, the whole country between this and the ridge beyond Libebe westwards, Lake 'Ngami and the Zouga southwards, and eastwards beyond Nchokotsa was one large freshwater lake. There is abundant evidence of the existence and extent of this vast lake in the longitudes indicated, and stretching from 17° to 21° s. lat. The whole of this space is paved with a bed of tufa more or less soft, as it is covered with soil or left exposed to atmospheric influences. Wherever ant-eaters make deep holes in the ancient bottom, freshwater shells are thrown out, identical with those now existing in the Lake 'Ngami and the Zambesi. The Barotse Valley was another lake of a similar nature, and one existed beyond Masiko, and a fourth near the Orange River. The whole of these lakes were let out by means of cracks or fissures made in the subtending sides by the upheaval of the country. The fissure made at the Victoria Falls let out the water of this great valley, and left a small patch in what was probably its deepest portion, and is now called Lake 'Ngami. The Falls of Gonye furnish an outlet to the lake of the Barotse Valley; and so of the other great lakes of remote times. . . . All the African lakes hitherto discovered are shallow in consequence of being the mere residua of very much larger ancient bodies of water. There can be no doubt that this continent was in former times very much more copiously supplied with water than at present, but a natural process of drainage has been going on for ages. Deep fissures are made probably by the elevation of the land, proofs of which are seen in modern shells imbedded in marly tufa all round the coastline. Whether this process of desiccation is as rapid throughout the continent, as, in a letter to the late Dean Buckland in 1843, I showed to have been the case

imagines that in the remote past, the Barotse Valley, the Linótkanóka, parts of the Káláhári, and the basin of the Zougá River, were occupied by a number of long, shallow, slug-shaped lakes, analogous in character to the existing members of the great Central African lake system recently explored by travellers. At that distant period, according to this hypothesis of the Doctor's, the present Káláhári wilderness, with its dreary expanses of wait-a-bit thorn and desert-melon, was comparatively fertile and well watered. The dried-up watercourses which furrow its sandy surface then conveyed to the lakes, the Orange River, the Limpopo, or the Zambesi, treasures of liquid to which it has been for thousands of years a stranger. Accumulations of lacustrine tufa, with fluviatile shells embedded, testify to the substantial correctness of this ingenious theory; and it is further supported by the occurrence of gorges, through which the superabundant accumulations of lacustrine water have, without doubt, forced their way to the ocean. But this process of draining out, to which Inner South Africa has evidently been subjected, must have taken place at a time so remote, that in all probability it occurred in the Quaternary geological epoch, as it is sometimes called, when gigantic quadrupeds are, by some geologists, supposed to have been the contemporaries of man upon the earth; and transpiring, as we presume it did, at so distant an epoch, the drainage of extensive ancient lakes to the ocean becomes entirely useless for all purposes as a theory explanatory of what has been taking place within the last few generations.

Putting aside, therefore, all idea of natural convulsions, we must seek reasons for the continued spread of drought in the physical characteristics of the 'Gariepine Basin itself, and in the customs of its inhabitants. And here doubtless we shall find the true solution of the difficulty.

I. In the first place, *the countries drained by the Great River are naturally arid*, both from their interior position and from the interposition of the Quathlamba Mountains between them and the Indian Ocean, whence the chief supplies of rain are evaporated. It will be necessary, therefore, to speak here of the three meteorological zones into which South Africa may be divided, and at the same time give a description of the different sections into which the 'Gariepine territories are apportioned by recent writers. The meteorological divisions may be regarded as three zones of climate

in the Bechuana country, it is not for me to say; but though there is a slight tradition of the waters having burst through the low hills south of the Barotse, there is none of a sudden upheaval accompanied by an earthquake. The formation of the crack of Mosioatunya is perhaps too ancient for that."—Livingstone's 'Missionary Travels in South Africa,' pp. 527, 528.

(*Livingstone*): the eastern, comprehending Zulu-land, Natal, Independent and British Kaffraria; the central, comprising a portion of the elevated Central Basin of the continent, and divided from the eastern by the Drakensberg, Malutis, and other ranges; and the western, including the Káláhári Proper, the wastes of Namaqualand, and the wilds of Bushmanland—the latter situated to the south of the Orange River.

The first of these, which may be called the zone of the Kaffirs, is pronounced by travellers to be decidedly fertile. It is covered with evergreen succulent trees, occasional extensive forests, and gigantic timber. The zone is comparatively well watered by numerous streams, and has a considerable annual rainfall.

The second, or zone of the Bechuana, consists for the most part of rolling plains or arid prairies, with but few fountains, fewer permanent rivers, and forests (*if such they may be called*) gradually diminishing to a final destruction, which from present appearances cannot long be delayed. Rain here, as a rule, is far from abundant; * irrigation is absolutely necessary to raise European grain, and droughts are of frequent occurrence.

The third, or zone of the Namaquas and Bushmen, sterile and barren in the extreme, is dependent upon thunder-storms alone for the rain, which rushes down its periodical rivers or supplies the vegetation of its deserts.

The prevailing winds of most of the country thus divided are from the north-east. Heavily laden with vapour from the Indian Ocean, the clouds, under the influence of these easterly currents, are driven over the Zulu territory, Natal and Kaffirland, watering those lands luxuriantly; but when the moisture-bearing nimbi arrive at the peaks of the mountain-ranges, not only have they parted with a large proportion of their water, but they are then on the edge of the more arid central basin, and begin to meet with the influences of the heated and naked plains, under the radiation from the surface of which, and in an increasing degree as the Bechuana tribes are passed and the Káláhári is reached, the clouds rise higher above the earth, the moisture evaporates into thinner vapour, and as a consequence fewer showers fall upon the hot thirsty soil beneath.

The further we journey from the Drakensburg eastwards, the greater becomes this diminution of water.

Leaving the mountains, the Lesuto or Basuto land, as it is frequently called, is, without doubt, the best-watered portion of the central meteorological district, mainly, it is presumed, on account of its being intersected by the Malutis range. Towards this im-

* The Lesuto is the exception.

portant section of country, from November to April, the north-east winds blow from the shores of Mozambique and the delta of the Zambesi immense masses of cloud, which sweep heavily over the earth, darkening the sky, and preceded in their course by dreadful peals of thunder. On reaching the high land, the aërial lake is shut in by the huge table-headed mountains; as a consequence, a rapid condensation takes place, and then a veritable deluge ensues. In a few moments cataracts rush from the mountain heights, the smallest and most thread-like rivulets are transformed into torrents, and the rivers, overflowing their banks, cover the plains: this sometimes lasts for days together (*Casalis*). It is from the accumulation of these waters that the Lekoa, the Caledon, and many other tributaries of the great Orange River, which with slow and majestic course flow to the westward across the vast plains of the centre of South Africa, take their rise. As the mountains, however, merge into the plains, and these again into the Káláhári, we are reminded by the gradually diminishing rivers of the continually increasing aridity of the soil, till we reach Great Namaqualand, where the occurrence of periodically filled water-courses again testifies to the descent of rain.

In this latter district, however, as well as in the desert, rain falls only from thunder-clouds. These rise from the north-east, and are always hailed with delight by the inhabitants of those parched and burning regions; but they are partial in the distribution of their precious treasure, the storms frequently passing over with tremendous violence, striking both European and native with awe at their terrific grandeur, while not a particle of rain descends to cool and fructify the barren waste. There is something terribly sublime in a real Namaqualand or Káláhári thunder-storm. The air becomes sultry and oppressive to an unusual degree; the whole animated creation is silent as death; not a breath of wind is perceptible. Low down on the horizon a dense black cloud emits a faint rumbling, which momentarily becomes louder and louder, while the threatening mass, ever increasing, gradually rises, lighted up with the quick flashes of forked lightning. At length a cloud of dust approaches, a storm of wind rushes over the plain, overturning trees, uprooting bushes, and sweeping everything before it in its tumultuous course; a few large spattering drops are heard, and then, with the almost simultaneous blinding glare of lightning and deafening crash of thunder, torrents of mingled hail and rain descend. In a few minutes the country is flooded; currents of turbid water, half a mile wide, roar through a ravine which has not shown a drop of water for years previously, rivulets flow where one would think water had never run before, and the ear is charmed with the sweet strains of a long-silent music. Perhaps in less than an hour the cloud has passed over, and may be seen speeding

onwards to pour out its treasures over many a sunburnt plain and parched mountain.*

Barren, burnt up, and roasted by the sun as are the desolate territories in the western meteorological zone, there are few spots nevertheless, even in the Káláhári Proper, which are covered with shifting sands, or are wholly desitute of vegetation. Even large trees are occasionally to be met with; and some of the periodical rivers of Namaqualand and the Cis-'Gariepine plateaux, in which water seldom flows, may be traced in their winding courses by the mimosa and camel-thorn trees that thinly line their banks. The parched and arid plains of a large portion of the northern division of the British colony support sheep on the thin sprinkling of grass and ice-plants which covers them; and undoubtedly the alpaca and the camel might here be introduced with advantage both to commerce and the highest interests of the native tribes. In fact, however barren and quasi-desert the different sections of the 'Gariepine Basin may be, there are none which do not support countless hosts of wild animals fitted by Providence for dwelling in droughty

* Rev. Henry Tindall's 'Lectures on Namaqualand.' Cape Town, 1856. Mr. Moffat's description of the winds and storms of Central South Africa is so striking that we cannot help giving it entire from p. 88 of his work:—

"Towards the end of the windy season the cattle snuff the green grass from the tropical regions. Their instinctive powers catch the scent of the green herbage. When this is the case, there is reason to hope that clouds will soon make their appearance from the opposite quarter. These winds I have learned from inquiry come from within the tropics, where rain has fallen and the cool air thereby produced rushes southward over the plains, filling up the space caused by the rarefaction of the air, owing to the approach of the sun to the tropic of Capricorn. The more boisterous these winds are, the more reason we have to expect rain. They cannot extend to any great height, as the thunder-clouds which follow, and which often commence with a small cloud in the opposite direction, increasing into mountains of snow, with a tinge of yellow, pursue an opposite course. These are preceded by a dead stillness, which continues till the tornado bursts upon us with awful violence, and the clouds have discharged their watery treasures. In such a case, there are almost always two strata of clouds frequently moving in opposite directions. The higher mountain-like masses, with their edges exactly defined, going one way, while the feelers, or loose, misty vapours beneath, convulsed and rolling in fearful velocity, are going another; while the peals of thunder are such as to make the very earth tremble. The lightning is of three descriptions, one kind passing from cloud to cloud. This is seldom accompanied with any rain. Another kind is the forked, which may be seen passing through a cloud and striking the earth; this is considered the most dangerous. The most common, not always accompanied by rain, is what we are in the habit of calling stream or chain-lightning. This appears to rise from the earth in figures of various shapes, crooked, zigzag and oblique, and sometimes like a waterspout at sea; it continues several seconds, while the observer can distinctly see it dissolve in pieces like a broken chain. The perpetual roar of awful thunder on these occasions may be conceived when twenty or more of these flashes may be counted in one minute. The lightning may also be seen passing upwards through the dense mass of vapour, and branching out like the limbs of a naked tree in the blue sky above. In such storms, the rain frequently falls in torrents, and runs off very rapidly, not moistening the earth, except in sandy plains, more than six inches deep. These storms are frequently very destructive."

countries; and the presence, wherever water can be found, of the wandering Bushman and Molala (poor Mochuana), the lean Mokáláhari, the stupid Koranna, and avaricious Namaqua, who make up the sum of the desert's human inhabitants, testifies that the great market of the world must derive *some* commodities even from its least inviting districts. Water, however, in the shape of a fountain (sometimes hot in Namaqualand), a sucking-place or subterraneous expanse of wet sand, generally in the bed of a periodical or dried-up river, or a shallow desert pool (*vley*), is an absolute necessity to the small communities which war, poverty, or choice, has led to the wilderness.

In those countries, generally remote from the sea, where the average rainfall is but a few inches in the course of a year, the diminution of an inch or two is felt with very much greater intensity than in those favoured lands where the rainfall is more abundant. In arid countries similar to the lands now under consideration, the revolution of the weather in cycles of years is also much more marked than elsewhere. It follows, therefore, that meteorologists find in such countries a sphere for their observations of the greatest interest and importance as connected with the phenomena of drought. In Britain, happily, a dry season conveys only an inadequate idea of drought; but in South Africa extreme droughts sometimes continue for whole years together, reducing the natives to the direst misery, depriving them of their scanty harvests, destroying their herds, and driving them from their homes to wander in search of subsistence.

During the year 1862, an unexampled and very widely-extended drought prevailed throughout the Cape Colony, and made itself felt far into the tropical regions in the neighbourhood even of the Great Lakes. It was very severely felt in the Lesuto, which is a territory generally blessed with abundant rains at stated periods. In this portion of the country, by the month of November, no traces of vegetation remained, the vast grass plains becoming mere sandy deserts from the excessive heat that prevailed. The clouds which overcast the heavens, apparently laden with fertilising treasure, if they would but part with it, seemed to mock at the hopes of the inhabitants. They passed away with the wind which bore on its wings thousands of tons of dry dust, gathered on its sweep over the parched ground for miles and miles; and which went on gathering and still gathering over mountains and plains, until it reached the South Atlantic and Indian Oceans, blasting and destroying vegetation on its way. The largest streams, too, ceased to flow. The cattle died by thousands, and famine began to appear throughout the land. Scarcely any crops could be got into the ground. The sun scorched the earth with its fire, and the rain-makers, whose assumed power over the elements had been

nearly overthrown by the advance of Christianity and civilisation into these regions, again attempted to re-establish their waning authority. The mighty Orange River could be stepped across by a child, and in its upper part at last ran dry, exposing in its bed, near Hope Town, the remains of a waggon which had been lost in a sudden flood while crossing the river some thirty years before. At last, when articles of food had risen to extremely high figures, breadstuffs being higher in price than during the Kaffir war, and cabbages selling at the rate of a penny the leaf at Colesberg, the heavens, whose inexorable serenity had lasted more than a year, were covered with clouds and drops of rain were heard to fall upon the parched ground, soon to be saturated with delightful showers. Although late in the season, the people were enabled to sow a little corn, and by degrees the visitation passed away, leaving behind it the remembrance of a dark dismal dispensation during the continuance of which men's hearts failed them for fear, thousands losing more than half their substance, and multitudes looking forward to absolute ruin and starvation.

The naïve description which Dr. Livingstone gives of the terrible drought that interrupted his initiatory labours as a Christian missionary when he established himself on the Kolobeng River, in the Bakwain territory, will be in the memory of most readers. How, for the space of two years, not more than 10 inches of water fell from the sky, till at last the river itself, a tributary of the fever-breeding Limpopo, ran quite dry. How the fishy inhabitants of the stream, deserted by the limpid waters, were killed in such immense quantities that hyenas from the whole country collected to the feast, and were unable to finish the putrefying carcases. Three years of unpropitious seasons had passed away, and during a fourth the fall of rain was still insufficient to bring the grain to maturity. Nothing could be more trying to the patience and endurance of the poor missionary. Deeper and deeper still the holes were made into the moist sand-patches in the bed of the river, in the hope of getting a little water to keep the fruit-trees alive for better times, but in vain. Needles lying out of doors for months did not rust, and a mixture of sulphuric acid and water used in a galvanic battery parted with all its water to the air, instead of imbibing more from it, as it would have done in a moister climate. Upon vegetation the effect was peculiar, for while the leaves of indigenous trees were drooping, soft, and shrivelled, they were not dead; and the leaves of the mimosæ were closed for repose, not only at night, as is usually the case, but at midday also, as if they required a double season of rest during the absence of rain. Notwithstanding many lowering clouds, the rain would not fall, and it was distressing to the mind of the good doctor to witness the earnestness with which deputa-

tions of heathen counsellors would entreat him to allow the Christian chief Sechelé, formerly a noted rain-doctor to make a few showers only for this once: again and again the clouds collected promisingly overhead, and rolling thunder seemed to portend refreshing showers; but next morning the sun would rise in a clear cloudless sky, without a drop of moisture.*

In such a country, afflicted at intervals with droughts of so devastating a character, the value of water can scarcely be too highly estimated by the inhabitants, nor ought any difficulty which can by possibility be surmounted, prevent the setting on foot of a feasible plan to alleviate the aridity that characterises the sterile parts of the Orange River Basin.

According to the latest geological observations on the neighbourhood of the Kúrúman, there is no perennial fountain in that part which does not come from beneath the quartzose trap that constitutes the filling up of the ancient valley, the igneous rock resting on silurian schists, from the surface of which the water appears to rise. We may remark by the way that this association of rocks is favourable, if we may rely on the dicta of experienced observers (*teste* Sir Roderick I. Murchison), to the probability of the existence of gold. But confining ourselves strictly to our subject, let us notice a few facts in connexion with the most accurately described fountain in South Africa, that called Gasigonyane, which gives rise to the river Kúrúman.

This remarkable spring issues from caverns in a little hill which is composed of blue and grey limestone mixed with considerable quantities of flint, but not in nodules, as found in beds of chalk. From the appearance of the caves and the irregularity of the strata, one might be led to suppose they have been the results of internal convulsions. The water, which is pure and wholesome, is rather calcareous. It is evident that its source must be at a very great distance, as all the rains which fall on the hills and plains for 40 miles round, in one year, could not possibly supply such a stream for one month. Although there are no sandstone formations nearer than 30 miles, great quantities of exceedingly fine sand come from it, and silicious particles appear to boil up out of the smaller springs in front of the larger, and are found in deposit in the bed of the river for miles distant—a proof this of the subterraneous passage of the water from the sides of the elevated basin to the centre, and a strong argument in favour of the probability of the success of artesian wells, if attempted. Large, however, as is the body of water rising from the Kúrúman fountain at its origin, like so many others in South Africa, it is largest at its source; and after running a course of 10 miles,

* Livingstone, p. 20.

becomes evaporated in its bed to the north-west of the settlement.

From the thick deposits of tufa visible on the stems of plants, and elsewhere near fountains, the supply of water must in former times have been much greater than at present; and next to the occurrence of ancient river-beds and watercourses in the desert, perhaps the most conclusive proof of the former well-watered condition of Bechuana-land is to be found in the numerous eyes of fountains partially filled up with sand, rushes, and tufa, which are to be met with in the neighbourhood of the Kúruman River and elsewhere. Many of these old fountains, by means of long and deep canals made by the Dutch boers from lower levels up to spots that indicate the former presence of water, have been resuscitated and now form permanent streams of great value for irrigation purposes. From the occurrence also of voluminous fountains like the Kúruman at an immense distance from the sources of water-supply, as well as from the fact of the rising of water from the surface of the silurian schists, which constitute the bottom rocks of the South African central valley, it is pretty certain that the supplies of fluid under consideration flow beneath the plains, from the well-watered table-headed mountains of the eastern ranges, in the same way that the waters of the Algerian Sáhára flow beneath the surface of the soil from the mountains of the Atlas chain, and reappear in the noted Bahr-taht-el-erd or underground sea of the plain of Tuggurt. There are no fountains in that part of Algeria, but the inhabitants dig through several layers of sand and gravel till they reach a flaky stone-like slate, known always to be above the Bahr. This layer is easily broken through, and the water thereupon rushes up so quickly that the man who digs through it is sometimes drowned.*

Made aware of these facts, the French Government some years ago conceived the idea of forming a chain of stations across the Sáhára, or a portion of it, from the Tell to Senegambia, each station to be provided with an artesian well.†

In 1856 French engineers dug a well of this character at Zamerna in the Oned-Ris. After 40 days' labour, at the depth of 60 metres, a supply of water yielding 4500 litres per minute was struck, which so surprised the Mogrebbin Arabs that they organised a grand festival in honour of the fountain. In the oasis of Sidi-Rached, the formerly extensive verdure was perishing, and with it, the supply from the spring, when the French sappers constructed a deep well yielding 4300 litres per minute. At the sight of this abundance of water, the tribe was beside itself for

* Morell's 'Algeria,' pp. 229 and 248.

† 'Revue de Paris,' Apr. 24, 1845; 'Chambers's Journal,' vol. iv. p. 92; Davies's 'Algiers in 1857'; 'Année Scientifique,' 1863; 'Almanach des bons Conseils,' 1864.

joy, and the old sheikh, falling on his knees, is said to have thanked God for sending the French to be the means of restoring the oasis to the possession of the tribe. During the last five years, fifty wells have been pierced in the Algerian Sáhárá, yielding 36,766 litres of the fertilising element per minute; an amount of water equal to the flow of several rivers. Notwithstanding this pleasing success, which has been followed by the settlement in villages of several hitherto nomadic tribes, and the planting of palm-groves, it is matter of grave doubt whether the whole chain can be successfully formed to the Senegal.

Sublime visionaries have not hesitated to assure us of the possibility of reclaiming even the Sáhárá, while more sober intellects have coolly argued the soundness and practicability of their bold theories; but if the digging of deep wells in the Great Desert should be followed by the growth of date and doum palms, the French have already taken a first and most energetic step towards the accomplishment of its reclamation; and reasoning from analogy, there can be but little doubt that if artesian wells have been found successful in the Algerian Sáhárá, they may also be practicable in the Lesuto, or the Bechuana country. The time may be nigher than we anticipate when the advance of railroads from the ports towards the interior, the increased civilization of the aboriginal tribes, and the gradual development of commerce may occasion the experiment to be tried as to whether deep wells may or may not afford perennial supplies of fluid, from subterraneous reservoirs of water beneath the central plains of South Africa; those supplies being derived from the gravitation of the rains from the mountains towards the centre.

II. But in the second place, if the ancient condition of the 'Gariepine Basin were more fertile than at present—and of this we think there can be no reasonable doubt—*is there any cause, besides the interior position of the country and the natural aridity of the soil, which occasions the advance of drought?* WE ASSERT THAT THERE IS, and that the effects of that originating cause are controllable, and indeed to a large extent preventable.

The human inhabitants themselves are a prime cause of the disaster, to account for which we find only partial reasons in the central position and physical characteristics of these regions. THE NATIVES HAVE FOR AGES BEEN ACCUSTOMED TO BURN THE PLAINS AND TO DESTROY THE TIMBER AND ANCIENT FORESTS. The Bechuana, especially the Batlapi and neighbouring tribes, are a nation of forest-levellers, cutting down every species of timber without regard to scenery or economy. The large traps or *hopos*, into which wild animals are driven for slaughter, must consume large quantities of trees in their construction, if we consider their immense size and the width of the avenues leading to them. Fuel,

implements of war, husbandry, &c., make away with a large quantity of wood. Dwelling-houses too are chiefly composed of small timber instead of stone, and their fences of branches and shrubs. Thus, when a site for a town is fixed upon, the first consideration is to be as near a thicket as possible, the whole of which is presently levelled, leaving only a few trees, one in each great man's fold, to afford shelter from the heat. The ground to be occupied for cultivation is the next object of attention, and the large trees being too hard for their native iron axes, they burn them down by keeping up a fire at the root. These supply them with branches for fences, while the sparrows, so destructive to their grain, are deprived of an asylum. The fences, as well as those in the towns, require constant repairs; indeed the former must be renewed every year, and, rather than gather or quarry stones to raise a substantial fence, a man will take a forked stick, a thong, and his axe, and occupy nearly a whole day in bringing from a distance a bundle of the hook-thorn to fill up a gap in his cattle or sheepfold.

By this means, the country for many miles around becomes entirely cleared of timber, while in the more sequestered spots, where they have their outposts, the same work of destruction goes on. Thus of whole forests, where the giraffe and elephant were formerly wont to seek their daily food, nothing is now left but a few stumps of camel-thorn which bear a silent testimony to the wastefulness of the Bechuana. In some parts of the country, the remains of ancient forests of wild olive-trees (*Olea similis*), and of the camel-thorn (*Acacia giraffe*), are still to be met with; but when these are levelled in the proximity of a Bechuana village, no young trees spring up to take their place.* When the natives migrate from a district, which may be after only a few years, the minor sorts of acacia soon grow, but the acacia giraffe requires an age to become a tree, and many ages must elapse before it can attain the dimensions of its predecessors.

The natives of many tribes, even the Bakáláhári of the desert have also the custom of annually getting rid of the tall dry grass by fire, which on some occasions destroys shrubs and trees to the very summit of the mountains, and must tend very much to produce an altered meteorological condition of the atmosphere, as well as to occasion that desolate and solitary aspect of the country, which European travellers speak of so deprecatingly. In Namaqualand the field (*veld*) is seldom burnt, the fierce and powerful sun seeming to perform that office for the natives, and destroying, in a dry summer, an immense proportion of the young shrubs and trees which spring up in a wet one; the effect of drought in this

* Livingstone, p. 112.

instance becoming in its turn an auxiliary cause of drought ; but there are vast regions in the basin of the Orange, and in the Cape Colony itself, bare of timber and bush, not only from the aridity of the soil, but from the pertinacity with which the natives and even colonists of European descent, adhere to the practice of producing an annual conflagration in winter, in order that the flocks may find an abundance of pasturage as soon as the spring sets in. In these bare regions, trees are hardly ever to be found, except on the banks of rivers or in high mountain-passes, as the fire penetrates into all the kloofs or ravines where the most luxuriant vegetation is found, and destroys it.

It appears certain that the farther we proceed westward from the mountains of Natal and Kaffirland, the less becomes the amount of rain bestowed by the clouds. The more denuded of trees and brushwood, and the more arid the land becomes, the smaller the supply of water from the atmosphere. The greater the extent of heated surface over which the partially exhausted clouds have to pass, the more rarefied the vapour contained in them necessarily becomes, and the higher the position which the clouds themselves assume in the atmosphere under the influence of the radiating caloric ; consequently the smaller the chance of the descent of any rain on the thirsty soil beneath. And the more the short-sighted colonists and ignorant natives burn the grass and timber, the wider the area of heated surface is made ; the further the droughty region extends, the smaller become the fountain supplies, and the more attenuated the streams, till they finally evaporate and disappear altogether. Thus the evil advances in an increasing ratio, and, unless checked, *must advance*, and will finally end in the depopulation and entire abandonment of many spots once thickly peopled, fertile, and productive.

In the case of the fountains at Griqua Town, referred to at the commencement, as having formerly poured forth an abundant supply of water, the accidental destruction of whole plains of the wild olive-tree by fire near the town, and the removal of the shrubs on the neighbouring heights, are known to have preceded the diminution of rain, and subsequent diminution of the springs, the subterraneous caverns which acted as reservoirs in the bowels of the earth ceasing to be supplied from the clouds. There can be no question that, hitherto, vegetation, like animal life, has, in South Africa, been wastefully and ignorantly destroyed, in direct violation of physical laws, which can never be broken with impunity ; and if we compare what is now taking place there with what has transpired in other arid countries, our conviction must deepen that it is not so much to the waywardness of nature as to the wilfulness of man that we must assign the recent extension of the Káláhári Desert.

If we cautiously and carefully examine the subject, we shall find that in many temperate countries, and even in some cold ones, the felling of forests has been attended by a greater or less diminution of moisture, and an alteration of the climatic conditions. This has been the case in the Canadian settlements and the Eastern States of the North American Union, which, since being won from the primeval forest, have markedly improved in general salubrity and meteorological condition.* Moreover, the general climate of Europe has undoubtedly undergone a great change since the destruction of the great belt of forest that, in the days of the old Romans, occupied its central portions. Not only has the climate of the old world become increasingly dry, but it has become warmer, the severe winters and heavy frosts described by ancient classical writers† being now almost unknown in the South of Europe. In these cases the felling of timber, because productive of the removal of dank vegetation and unwholesome moisture, has operated to the improvement of the soil, increasing its producing capabilities, and occasioning it to be better fitted for the residence of man. The general character of ancient Europe, both insular and continental, whilst yet unreclaimed and overspread with forests, would naturally be more humid, and consequently colder. When cultivation and a vast increase of population occasioned the removal of the timber, the freezing of the Danube and Tiber would gradually become matter of history, and heavy frosts in Greece and Italy a cause of wonder.

While the climate of our quarter of the globe has thus, we repeat, been ameliorated by the removal of the superabundance of wood, on the other hand, in the steppes of Southern Russia, in Northern Africa, in some parts of Italy, Greece, European Turkey, and Persia, many a bare tract exists which owes its origin to the folly or neglect of rulers or subjects, who have removed, to the extent of absolute extermination, those natural protectors of humidity—the trees—and have thus turned fruitful gardens into a waste.

In Greece and Asia Minor the traveller finds the reality fall far short of the description of the scenery given by the celebrated writers of olden time. The mighty streams so magniloquently described in the poems of antiquity, are found to be mere rivulets compared with the grandiose accounts of the old epics. The sparkling cascades and fountains which, in enchanting the eye, also prompted the verse of the classic writers, have disappeared under the powerful influences exerted by ages of war, misrule, and

* Daubeney's 'Lectures on Climate,' p. 114.

† Virgil's 'Georgics,' lib. iii. 349-370. Ovid's 'De Ponto,' lib. iv. eleg. 7 and 9. For other authorities, *vide* Daubeney 'On Climate,' pp. 104 *et seq.*; *vide* also Milner's 'Crimea,' pp. 16 *et seq.*

oppression. Districts once covered with rich crops of corn, with olive and vineyards, orchards and groves, are at the present time mere expanses of sand or barren rocks, or arid flats.* The same remarks are also true of Syria and Palestine, where the land "flowing with milk and honey" has, under the iron heel of the obstructive and oppressive Turk, become in many parts a wilderness covered with stones and ruins.

Proceeding still farther to the East, perhaps there is no part of the world where evidence accumulates upon us of the evil effects resulting from the unwise destruction of timber, than in the more arid provinces of Persia. Here, under the ignorant government of the Shahs, whole tracts of country, once thickly peopled, well watered, fertile, and extensively wooded, are little better than barren wastes, over which the traveller may pass and find no sweet bubbling fountain at which to quench his thirst, no solitary tree spreading its wide branches to produce a welcome shelter for his wearied limbs, no village or hostelry to which he can repair for hospitality. Instead of these, he will pass the remains of canals, bridges, and ornamental fountains, from which the water has been evaporated for centuries; he will encounter ruined houses, fallen walls of gardens, deserted villas, ancient churches and mosques, all baking in the fiery Persian sun, and testifying to the misrule which has so long prevailed here, as in other wretched countries of Asia. A late writer in '*Chambers's Journal*,' on the subject of the failure of springs in the East,† asserts that, as far back as the seventeenth century, a Persian nobleman, conversing with a European traveller (Tavernier), assured him that within a comparatively few years no less than four hundred springs had failed in the small province over which he himself ruled; a proof of the fatal consequences of permitting the destruction of timber for fuel without making provision for a fresh growth: for in the ancient days of Persia's greatness, before a Mahometan fatalism had begun to exert its baneful influence upon the Persians, a very different state of things existed. Then groves were planted on eminences; the streams were fringed with wood; orchards and pleasure-gardens, famous for their exquisitely-scented roses, adorned the slopes of the hills; and by careful irrigation through a thousand small canals, industry and energy were enabled to gather in abundant harvests of the fruits of the earth. With the decadence of the political power of Islamism, however, the prosperity of Persia, such as it was under the caliphs, began to pass away: and ruined cities, aqueducts, palaces, and temples, standing in the midst of useless deserts, now offer their

* St. John's '*Manners and Customs of Ancient Greece*,' p. 370; also Daubeny '*On Climate*,' p. 107.

† '*Chambers's Journal*' for July 4th, 1863.

united testimony to the ignorance and incapacity of Mahometan princes.

In our own British colonies of Barbadoes,* Jamaica,* Penang,† and the Mauritius,‡ the felling of forests has also been attended by a diminution of rain. In the island of Penang, the removal of jungle from the summits of hills by Chinese settlers speedily occasioned the springs to dry up, and, except during the monsoons, no moisture was left in the disforested districts. In the Mauritius it has been found necessary to retain all the lands on the crests of the hills and mountains in the hands of Government to be devoted to forest, the fertility of the lower lands having been found by experience to depend upon clothing the hills with wood.

Many provinces of India—more especially the Punjāb and the Dekkan,§—may also be adduced in support of the assertions that have been made, the vicinity of hills having become deserted in consequence of the failure of springs following the destruction of woods: but where the digging of canals has been accompanied by the planting of trees along their banks, the departed barrenness has been again transformed into fertility.||

In the steppes of Tartary we have abundant proof that physical changes of great magnitude, and similar in character to those which have been noticed on the Orange, have taken place within the historic period. Notwithstanding the present entire absence of trees, and the occurrence of a drought which regularly prevails for half the year, the beds of numerous rivers that once fertilised the country may be traced with the utmost facility to the sources from whence the waters originally flowed. In the time of Mithridates the Crimean steppe was famous for its fertility, and teemed with inhabitants, of which we have sufficient evidence without referring to history, in the ruins of numerous towns and cities, and in the abundance of tumuli which strew the plains. Prince Woronzow, an enlightened Russian nobleman, assured the traveller Spencer¶

* Moffat's 'South Africa,' on the authority of the 'Philosophical Transactions,' vol. ii. 294.

† 'Journal of the Indian Archipelago.' Logan, Singapore.

‡ Thornton's 'History of India.'

§ The author of the article on the Failure of Springs in the East.—'Chambers's Journal,' 1863.

|| The island of Ascension having lost its only spring a few years since, in consequence of the reckless destruction of its trees (a process which the Cape de Verde Islands having also undergone, have also been visited with in like manner), a systematic replanting under the auspices of English botanists has resulted in the restoration of the water, which it is hoped may now prove permanent, proper protection being afforded to vegetation. On the authority of Dr. Daubeny, it may also be stated that Lower Egypt, which is usually cited as a country where rain never falls, has lost this character, having experienced of late occasional showers of a heavy description in the neighbourhood of Cairo and Alexandria. This remarkable change has been coincident with an extensive planting of trees in the neighbourhood of those cities, under the orders of the late Pasha.

¶ Travels in European Turkey, &c.

that nearly the whole of western Tartary might be rendered a fertile and productive country by the adoption of judicious means. In his opinion, all that is wanted to change the entire character of the climate is to drain the marshes, dig artesian wells in the plains for the purposes of irrigation, and encourage the growth of timber. As the soil is generally of a dark loamy colour, and as, moreover, wherever the ground has been excavated, the roots of gigantic trees have been discovered, testifying to the former well-wooded condition of these now absolutely treeless plains, there can be little doubt that a paternal government might soon verify the truth of this enlightened nobleman's suppositions by a proper system of colonization.

In Northern Africa, Egypt and Lybia have witnessed the advance of the desert since the decline of the Roman empire; and Algeria, although it has made rapid strides under its French conquerors, is still, in great part, the home of frogs, from the prevalence of marshes, and a nest of locusts from the barrenness of its plains. Algeria can only be rendered as fertile as it ought to be on condition that the French cover a third part of its surface with wood, and convert its rapid unnavigable rivers exclusively to the purposes of irrigation. The blindness of civilised states (who in this particular are little better than the uncivilised barbarians whose destructive practices we have been decrying), in foolishly laying the axe to the root of all trees, has been manifested in North as in South Africa; and until the carob, the olive, the cork-tree, the mastich, the oak, and the myrtle, are cultivated by the side of all waters, the rich harvests which rendered ancient Roman Africa the granary of the Imperial City need not be expected. Timber-trees, with roots which strike deep into the earth, it is worthy of remark, alone thrive here in summer, as they strike down to the humid soil under the parched crust; they should therefore be extensively encouraged for the shelter of water and of crops, since sheltered fields, according to an established fact, yield most corn.*

In this French colony, it must be noted further that the Wady-Kniss, called by Nicholas de Nicolai (1587) the Savo, used to be a large stream, and is now only a thread. It contains, however, many dry springs, the drying up having in all probability resulted from the stripping of the woods.†

Nor is the new world without evidence that the burning of prairies and pampas, and the wanton destruction of timber by Indian tribes and marauding Spaniards, has resulted in a deterioration of climate. Father Domenech, in his account of the Great American Desert, speaking of the celebrated Llano Esta-

* Morell's 'Algeria.'

† Baron Baude's 'Algeria,' vol. i. pp. 78-81.

cado, or Staked Plain, says the prolonged drought, the nature of the soil, and the habit that the Indians have of *annually setting fire to the prairies*, account for its aridity. The country of New Mexico, since the invasion of the Spaniards, has become dry, arid, and deserted. Many of the Indian populations were suddenly deprived of both wood and water. Perpetual droughts followed the clearing of the forests. Both rivers and their sources dried up. A multitude of streams in Texas and New Mexico have ceased to flow—some for centuries, others only within a few years; and their banks, formerly gay with verdure, plants, flowers, and trees, now disappear under heaps of sand, and present everywhere a scene of desolation.

On the banks of the Rio Verde, in the new territory of Arizona, abound ruins of stone dwellings and fortifications, situated in valleys where traces of former cultivation and of small canals for irrigation are yet visible. The traditions of the Indians, as under similar circumstances in Bechuanaland, point to a time when the elevated table-lands around were covered with magnificent and fruitful vegetation. But the timber was destroyed, the prairie-grasses were burnt off, and the Great Desert thereupon asserted its right to consider the newly-devastated lands as portions of its own territory, and evaporated the springs and rivers under the influence of its desiccating atmosphere.*

Turning to South America, Humboldt informs us that the Lake of Valencia, in the state of Venezuela, is calculated, being destitute of an outlet, to gauge with the greatest nicety the increase or diminution of the rivers that pour their waters into it. From a careful examination, that accurate observer was convinced, both from the form of the surrounding hills, and from the occurrence of fresh-water shells in the heart of the country, that a great retrogression of the waters had taken place. No evidence, however, exists that any considerable diminution of them has taken place in very recent times, although within thirty years preceding Humboldt's visit, the gradual desiccation of this great basin had excited general attention. This diminution is not to be accounted for, our traveller declares, by imagining the existence of subterranean channels, as some suppose, but by the effects of evaporation, increased by the changes operated upon the surface of the country. Forests, he says, by sheltering the soil from the direct action of the sun, diminish the waste of moisture; consequently, when they are imprudently destroyed, the springs become less abundant, or are entirely dried up. Till the middle of the last century, the mountains that surround the valleys of Aragua, where the lake is situated, were covered with woods, and the plains with thickets

* Domenech's 'Deserts of North America,' vol. i. p. 380.

interspersed with large trees. As cultivation increased, the sylvan vegetation suffered; and, as the evaporation in this district is excessively powerful, the little rivers were dried up in the lower portion of their course during a great part of the year. The land that surrounds the lake being quite flat and even, the decrease of a few inches in the level of the water exposes a vast extent of ground; and as it has retired, the planters have taken possession of the new land.*

Five-and-twenty years after the visit of Baron Humboldt to Venezuela, M. Boussingault relates that, the country being desolated by the War of Independence, the lake was fuller than formerly, owing to the partial return of the land to a state of nature on the abandonment of many plantations. Hence, as timber was no longer felled to the same extent, rain fell in greater abundance, and the lake advanced in consequence.† Another lake without an outlet, situated in New Granada, supplied Boussingault with a second and similar instance of the connexion between the quantity of timber and the amount of rain. Here the recession of the waters was a matter of general notoriety, and coincident with the diminution had been the clearing of the surrounding forests, to afford fuel for the salt-works that exist in the neighbourhood. Nor could this have arisen from any change of climate; for in other places in the same neighbourhood, where no clearings have taken place, and where everything has continued to be left to nature, the level of the lakes has undergone no change from time immemorial.

It being matter of notoriety in these instances that the removal piecemeal of forests, and the burning off of jungle from the summits of hills, has occasioned the uplands to become dry, and the lowlands to lose their springs, it becomes of extreme importance to our South African fellow-subjects, that the destruction of the arboreal protectors of water should be regarded as a thing to be deplored, deprecated, and prevented; and that public opinion on the matter should be educated. At no period more than the present, when the effects of the terrible visitation of 1862 have not yet ceased to be felt, could the consideration of every topic connected with the subject of drought and its causes be more appropriate. And the establishment of private mercantile undertakings at Walfisch Bay, the development of the copper-mines in Little Namaqualand, the gradual extension of British emigration to the prairies of the Free State and the North generally, the growth of British influence in the townships and homesteads of those prairies, culminating in the election (1864) of a British subject to the Presidency of the Republic, the desire which is increasingly mani-

* Macgillivray's Translation of Humboldt's Travels, pp. 173 *et seq.*

† Daubeney's 'Lectures on Climate,' p. 105.

festated for the re-establishment of British supremacy there, as well as the advances made in civilisation by the Griqua and other native tribes, all combine to add to the importance of this question, not only to the scientific world, but to the colonial authorities at the Cape.

Up to the present the efforts made to employ irrigation in raising crops have been on the smallest scale, and little or no attention has been paid to the planting of trees for the purpose of protecting water, save at the Kúruman mission-village, where a considerable number have been planted by the veteran Moffat. Impelled by the best of motives, that of ameliorating the social as well as moral condition of the natives, whose tongue he himself reduced to grammatical rules, this gentleman has by precept and example been endeavouring to prevent that wholesale and wasteful destruction of timber which has prevailed from time immemorial. He declares his conviction that in process of time the natives will come to understand that trees are the true rain-makers, and to believe in the philosophy of encouraging their growth. He does not despair, he says, of eventually seeing the whole of the population—some of whom are now commencing the use of stone fences and brick houses—so fully satisfied on this point, that they will find it for their own interest, as well as contributing to the beauty of the country, to plant trees; more particularly as very few others, besides those indigenous to the soil, will grow to any extent.

But we must not stop here. The evil is one of such magnitude, and likely to bear so abundant a harvest of misery in the future, that the authority of law, wherever practicable, should be invoked in order to institute preventive measures. Not only should fuel be economised, but the real interests of the British colonies and Dutch republics, for many long years to come, would most certainly be consulted by the passage of stringent enactments which should in the first place forbid, at any season or under any circumstances whatever, the firing of grass on field or mountain. The absolute necessity which exists for keeping as large a surface of the ground as possible covered with vegetation, in order to screen it from the solar rays, and thus to generate cold and humidity, that the radiation from the surface may not drive off the moisture of the rain-bearing clouds in their season, ought to compel the rigid enforcement of such a legal provision. Those colonial acts on this subject which are already in existence—for the Colonial Parliament at the Cape has found it necessary to pass restrictive measures—are not sufficiently stringent to be of much service, inasmuch as they are not entirely prohibitory, permitting the burning of the field at certain seasons of the year.

In the second place, provision should be made in connexion

with every work of irrigation to keep up at least a fringe of trees on the banks of canals, rivers, and watercourses. The damming of streams with strong works, as in Australia, for the purpose of preserving water in reservoirs and tanks, would afford a very favourable opportunity for introducing into private bills brought before provincial Houses of Legislature, clauses insisting upon the carrying out of such a provision. Irrigation companies and others would also find it to their advantage to cover with such trees as are indigenous to the country, or any others which could be grown with profit, all hills and elevations unsuitable for pasturage in the neighbourhood of their works. In the old slave-times, the Dutch farmers were accustomed to plant a great many firs, oaks, and poplars; but since the emancipation of the Hottentots, the avenues and groves have been, and still are, foolishly cut down for timber, fuel, &c., and they are seldom replanted. On the other hand, the sandy desert near Cape Town, called the Cape Flats, is now being planted over with trees, shrubs, &c., as an experiment. The result so far is encouraging, and renders it worthy of imitation wherever practicable. What was formerly a vast sheet of drifting sand is now covered with vegetation; and from private information lately received, we learn that some parts are being brought into a high state of cultivation.

The institution of *pépinières* or nursery-grounds, whence young trees could be distributed under the direction of experienced practical men, would also be a great boon. Considerable attention has been paid to the flora of South Africa by gentlemen of note in the world of natural history; but South African arboriculture is still a field for investigation worthy of entry, and would reward research. The trees of Namaqualand and Damaraland are principally acacias, and very few attempts have been made to raise others there. In the neighbourhood of Cape Town oaks, poplars, and firs flourish, and should be multiplied indefinitely. Notwithstanding the excuse of flock-masters, that the pasturage is required in the neighbourhood of water for sheep and horned cattle, and that attention cannot therefore be paid to tree-planting, it becomes obvious that unless as much rocky mountain and hill as is practicable for the growth of timber, added to a considerable breadth of good land, be covered with wood, the present pasturages must deteriorate, and the diminution of water become probable; whereas, if attention be now paid to the growth of Australian trees, hard wagon-woods, Algerian or other timber-trees, the lumber would in the course of years become a source of revenue; while the impediment to the free circulation of air arising from the thick foliage, would combine with other causes in condensing vapour, and thus add to the water-supply, a fact which is sufficiently patent in warm climates to be undeniable.

Along the Orange River and as we approach the tropic, date-palms and doum-palms might be profitably planted near water. The dwarf-palm or palmetto of South Europe, and that of South Carolina, ought also to flourish in the opinion of Dr. William Harvey,* the Dublin Professor of Botany; and even the cocoa-nut, as a shade-plant, but scarcely in the hope of its fruiting. Some of the dwarfer and more leafy Eucalypti of New Holland would also serve a purpose. The various native species of *Rhus*, of *Euclea* and of *Royena*, may be mentioned as plants well adapted for shelter; also the dense-headed acacias, of which several species grow about the Orange River, as well as the willow of the 'Gariap. Other trees affording timber might doubtless be grown for various purposes in the neighbourhood of markets for the wood; but to do this advantageously would necessitate a thorough investigation on the spot of the capabilities of the region. In point of fact, the full consideration of this interesting subject in all its bearings can only be pursued in the colony itself under the sanction of colonial savans, and no money granted by a provincial Parliament would be better spent than a small sum devoted by authority to the investigation of this branch of economic botany.

In concluding this imperfect glance at a very comprehensive subject, we may observe that such is the incurable aridity of many portions of the Orange River Basin and its neighbourhood, that perennial fountains and permanent pools are not, under any circumstances, to be expected. In these districts, Bushmanland, Namaqualand, and Damaraland—not to include the Desert Proper—the want of permanent supplies of water condemns to a more or less nomadic life the pastoral inhabitants who dwell there; they are forced to wander with their flocks and herds in search of pasture. Deep wells in places where limestone rocks crop out, as at Barmen, Wesleyvale, &c., might possibly supply a considerable quantity of water, should it ever be worth while to construct them. A considerable proportion of the rainfall might be also arrested in the ravines or wadys. But in so poor a country, where clay is so rare and sand so abundant, the surface waters drain rapidly off into the arid river-beds, and almost immediately disappear. The habitability of these districts seems to depend upon the formation of pools or lagoons in places where a thin stratum of mud retains with more or less completeness the water above it. Sheltered by trees and vegetation, such pools might hold out until the next rains. Or perhaps the practices in vogue in Australia might be efficacious in South Africa, viz., damming the smaller watercourses

* To this gentleman, who is curator of the University Herbarium at Dublin, as well as to Mr. Francis Galton, the South African traveller, and to Mr. J. A. St. John, author of the 'Manners and Customs of Ancient Greece,' &c., we are indebted for many important hints and observations.

so as to make artificial reservoirs; then encouraging a judicious vegetation to check evaporation; and finally trusting to the stamping of the feet of sheep to harden by puddling the surface of the land in the neighbourhood of the newly-formed pool.*

X.—*On the Climate of the North Pole, and on Circumpolar Exploration.* By W. E. HICKSON, Esq.

Read, April 10, 1865.

A REVIVAL of interest in Arctic discovery has led me to ask attention to some astronomical considerations, relating to the probable climate of the North Pole, and, connected with them, to other data, bearing upon the question of the direction that should be given to any new expedition that may be organised for the Polar Seas.

It has always been popularly supposed that the immediate areas of the Poles must be the coldest regions of the globe, because the farthest points from the equator. Hence the argument that the higher the latitude the greater must be the difficulties and dangers of navigation; a belief encouraged by a work of some reputation, the ‘*Révolutions de la Mer*’ of M. Adhémar; who, seeking to account mathematically for the shifting, in times past, of the bed of the ocean, imagined ice to accumulate at the Poles, continuously but unequally, in such immense masses as to disturb the earth’s centre of gravity. It was, perhaps, under the influence of this extreme hypothesis that a writer in one of our best weekly periodicals was induced recently to remark, by way of objection to Capt. Osborn’s proposal, that “the hardships and perils of Arctic expeditions have only yet been skirted,” and that “new horrors await new exploration.”

Quite an opposite opinion, however, had begun to prevail among meteorologists on the publication, in 1817, of the *Isothermal System* of Alexander von Humboldt, which showed that distance from the equator is no rule for cold, as the equator is not a parallel of maximum heat. The line of maximum heat crosses the Greenwich meridian, in Africa, fifteen degrees north of the equator, and rises, to the eastward, five degrees higher; running along the southern edge of the Desert of Sahara.

In 1821 Sir David Brewster pointed out, in a paper on the mean temperature of the globe, the probability of the thermometer being found to range ten degrees higher at the Pole than in some outer parts of the Arctic circle. No new facts have since been

* For this last suggestion I am indebted to Mr. Francis Galton.